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Managing the 8 Wastes of Lean in a HEI: An ISM-MICMAC Approach

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Managing the 8 wastes of Lean in a Higher Education Institution: An ISM-MICMAC Approach

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Abstract. A Higher Education Institution (HEI) is required to be more competitive in maintaining its sustainability. The large number of stakeholders of a HEI makes it difficult to be agile in the intense competition. One of the concepts that can be used to improve the agility of a HEI is Lean philosophy. Lean philosophy focuses on eliminating waste in the process of creating value for stakeholders. Previous research has succeeded in identifying a number of wastes in the operational activities of a HEI. Moreover, this study aims to develop a series of actions to eliminate wastes that have been identified. Interpretive Structural Modeling (ISM) and Matrices d Impacts cross-multiplication applique a classmate (MICMAC) are employed to model the relationship between wastes based on their mutual influence. ISM forms a hierarchical structure of interrelationships between wastes. Meanwhile, MICMAC will classify wastes based on their level of influence in a cartesian diagram. These models will help analyze the root cause of the problem so that effective waste elimination actions can be arranged.

1. Introduction

Lean manufacturing is a management practice that focuses on increasing value for customers through waste elimination [1]. This concept emerged when the automotive industry had to fight in a competitive global market [2]. Today when 'quality of life' is becoming so important for the society, the service industries are under the spotlight to improve their process quality in order to survive in the business competition [3]. To achieve this goal, lean principles that are successfully implemented in various manufacturing industries, have begun to be adopted in the service industry and later known as lean service [4]. Lean service then developed into one of the most reliable alternative approaches in the service industry in an effort to increase the effectiveness and efficiency by reducing waste or non-value-added activities. Practically, lean service is closely related to standardization of work processes so that critical problems in the organization are clearly visible and human resources are stimulated to think critically in solving problems and in improving work flow [5].

Lean principles are easily adapted in various service sectors. Various scientific publications prove that lean service is successful in improving the quality of operations in various service sectors, ranging from commercial ones such as hotel [6], hospital [7], bank [8], school [9] to public services [10]. Among the various service sectors, the implementation of lean service that is being developed is in higher education institutions (HEIs) [11]. The implementation of lean service in HEIs is known as Lean Higher Education (LHE) [12]. LHE stems from the many HEIs that are committed to improve their process because they are considered to be inefficient, expensive, and labor intensive [13]. The society is required to be more 'knowledgeable' but the increasingly severe economic challenges encourage them to look for institutions that provide affordable education. Therefore, HEIs face tremendous challenges and are under pressure to become more responsive to customer needs and gain excellence [14]. Improvement efforts initiated by HEIs are often underestimated because they only last in the short term until they end in failure. In fact, HEIs have a lot of potential for driving LHE initiatives because lean management has been included in the curriculum at various HEIs in the world [15].

HEIs have benefited greatly from the implementation of LHE [16]. Balzer et al. [13] conducted a study on five cases of implementing LHE in the USA and found that LHE provided benefits for universities, employees, and individuals served. Furthermore, Allaoui and Benmoussa [17] found that college employees were motivated to make changes with LHE due to high level of education, dissatisfaction with working conditions, good impression on the change project, curiosity, good relationship with management, lack of routine, good relationship with co-workers, and its positive impact on employees. However, the implementation of LHE has more challenges than lean services in general. Waterbury [18] found that there were eight challenges that emerged in implementing LHE in seven HEIs: scheduling, time, lean competency, competing needs, seeing differently, skilled facilitators, financial resources, and project selection. The challenge arises because education is a service that has many stakeholders both inside and outside the organization with several conflicting objectives [19].

Different HEIs also lead to differences in the approaches, methods, and practices used in the implementation of LHE [20]. However, the main objective of implementing LHE has been agreed: to add value to stakeholders by reducing waste so that HEIs get the opportunities to improve academic and administrative processes [21]. The eight waste categories that appear in HEIs are identified as excess transportation, underutilized human resources, inventory, excess motion defects, overproduction, waiting, over processing, and excess information [22]. These wastes resulted in disruption of administrative and academic processes so as to create stakeholder dissatisfaction. Therefore, HEIs must not only identify the wastes but also must find a way to eliminate the wastes so that continuous process improvement can occur. Kazancoglu & Ozkan-Ozen [23] identified wastes in a HEI in Turkey and used a fuzzy decision-making trial and evaluation laboratory (DEMATEL) in building a structural model that was used as the basis for proposing actions to eliminate wastes. However, the weakness of the structural model produced by DEMATEL only classifies factors based on the magnitude of the influence. DEMATEL cannot identify the interplay factors in a structural model. Klein et al. [24] proposed a waste management framework for a HEI in Brazil which was built using Analytical Hierarchy Process (AHP) method. The weakness of the proposed waste management using the AHP method is that waste management will start from the waste that is considered to have the highest subjective importance and ignore the interrelationship with other wastes.

One of the proposed approaches to find ways in waste elimination is Interpretive structural modeling (ISM). Rawabdeh [25] states that all types of waste are interdependent, and each type has an influence on each other; and simultaneously influenced by others. ISM is a method for modeling direct and indirect relationships between various factors. ISM describes a hierarchical structure and partition level so as to visualize the implementation structure in a better way [26]. The use of ISM which is integrated with the Matrice d' Impacts Croisés-Multiplication Appliquée á un Classement (MICMAC) has proven to be effective in finding solutions to a problem [27]. Jadav et al. [28] used the ISM-MICMAC approach in designing a framework for implementing lean management. In this study, ISM and MICMAC are used to model the structure of the relationship between wastes in a HEI that so that the root causes of the problem can be identified and a series of waste elimination actions can be proposed.

2. Methods

The description of the research design follows the classification in the research onion proposed by Saunders et al. [29]. The research strategy is a single case study with a cross sectional time horizon. The case used in this study is a private HEI in Surabaya, Indonesia which has been accredited A. Accreditation A indicates the highest recognition of the performance of a HEI in Indonesia. Stakeholder expectations for A-accredited HEIs will also be very high. Therefore, an A-accredited HEI can become a single extreme case study that can provide insights as well as lessons learned regarding the issue of lean waste management in HEIs. The selection of an A-accredited HEI was carried out by convenience sampling by considering the accessibility of researchers.

The stages of this research start from determining eight categories of waste: defects, overproduction, waiting, non-utilized talent, extra transportation, excess inventory, extra motion, and extra processing. Then, the identification of waste modes in each waste category is carried out through unstructured interviews and direct observation of lecturers at the HEI. Furthermore, a structural model was developed for the identified waste modes using Interpretive Structural Modeling (ISM) approach. The purpose of developing the structural model is to find a set of waste elimination actions. The ISM procedure begins with establishing the relationship between waste modes through a focus group discussion (FGD) from a panel of expert. The panel of expert determines the relationship between waste modes through pairwise comparisons using four symbols:

V: waste i influences waste j, but waste j does not influence waste i;
A: waste j influences waste i, but waste i does not influence waste j;
X: waste i influences waste j and waste j influences waste i;
O: waste i and waste j are not related and vice versa.

The result of the FGD is a structural self-interaction matrix (SSIM). The SSIM is then converted into an initial reachability matrix (IRM). IRM shows the relationship from waste i to waste j expressed in binary (0 or 1). Table 1 shows the conversion of the type of relationship waste i to waste j from the symbols used in SSIM to binary numbers.

Table 1. The conversion of SSIM symbols

Symbol	i to j relationship	j to i relationship
V	1	0
A	0	1
X	1	1
O	0	0

The IRM then checked for its transitivity. Transitivity is expressed if A is related to B and B is related to C, then A is also related to C. The IRM whose transitivity has been checked is called the final reachability matrix (FRM). Once the FRM is formed, the next step is to determine the reachability set (R), the antecedent set (S), and the intersection (R∩S). The reachability set is a series of waste modes in a column where all waste modes in row i of FRM have a value of 1. The antecedent set is a series of waste modes in a row where all waste modes in column j of FRM have a value of 1.

After getting R, S, and R∩S, the hierarchical structure can be determined. The order starts at level-I which is placed at the top of the hierarchy. The selected waste modes are the waste modes that have R equal to R∩S. For the next iteration, waste modes that have entered level-I are removed from the FRM and the same process is carried out starting from determining R, S, and R∩S. And so on until the level for all waste modes is determined.

FRM is also used to construct a MICMAC (Matrice d'Impacts Croisé Multiplication Appliqué un Classement) cartesian diagram. MICMAC cartesian diagram is used to classify waste modes into four groups: autonomous, dependent, linkage, and driver. Cluster I, autonomous, consists of waste modes with weak driving power and dependency. Cluster II, dependent, consists of waste with weak driving force but strong dependence. Cluster III, linkage, consists of waste modes with a strong driving force and dependence. Finally, cluster IV, driver, consists of waste modes with a strong driving force and weak dependency. The structure of this diagram consists of the dependencies (x-axis) and driving forces for the (y-axis). The strength of the dependence of each element is calculated from the FRM by adding up all the numbers in the appropriate column. Meanwhile, the driving force of each element is calculated from the FRM by adding up all the numbers in the corresponding row. Then, the value of the dependence and the driving force of each element becomes the position of each element which refers to the x and y axes in the cartesian diagram.

3. Results

Table 2 shows 18 waste modes identified through interviews and observations. The waste modes are then ranked based on the frequency of their occurrences from the observations. The waste category that does not bring up the waste mode from the results of interviews and observations is extra transportation. Thus, extra transportation is not a significant waste category in this case. Meanwhile, the category of waste that produces the most waste modes is waiting.

Table 2. Identified waste modes

Rank	Waste Category	Waste Mode
1	Overproduction	Working outside the hours to perform administrative work
2	Waiting	Facility repairs take a long time
3	Non utilized talent	The lecturer does not participate in community service every semester
4	Defects	The lecturer is unable to locate a file
5	Defects	The projector's connecting wire is faulty
6	Waiting	The lecturer fails to submit reports by a stipulated deadline
7	Extra processing	The lecturer spends a lot of time looking for documents, files, and journals
8	Waiting	The lecturer takes a long time to respond to student messages and questions
9	Extra processing	Multiple information channels are used to receive information (WhatsApp, email, hard copy, etc.)
10	Overproduction	Every semester, the teaching load is overwhelming
11	Inventory	The lecturer uses the same exam questions from the previous year
12	Waiting	Assignments are not submitted on time by students
13	Non-utilized talent	Every semester, the lecturer does not undertake research
14	Defects	The course schedule is changed by the lecturers
15	Defects	Students are re-examined by the lecturer
16	Waiting	The lecturer is late in meetings
17	Waiting	The lecturer waits for students to come in to class
18	Non-utilized talent	The lecturer is assigned a task outside of their expertise

Next, the focus group discussion (FGD) was conducted with the expert panel to determine the contextual relationship between waste modes. The results of the FGD are outlined in the structural self-interaction matrix (SSIM) in Table 3. The SSIM in Table 3 is then converted into an initial reachability matrix (IRM) in Table 4. IRM which has been tested for transitivity becomes the final reachability matrix (FRM) (see Table 5). The transitivity test triggered 55 new relationships in the FRM. After the transitivity test, the driving power and the dependence were calculated for developing a MICMAC cartesian diagram. FRM is then used as the basis for determining the reachability set (R), the antecedent set (S), and the intersection (R∩S). If R is the same as R∩S, the waste mode is allocated into a hierarchical structure. The waste that has been allocated in the hierarchical structure is removed from the FRM and the new R, S, and

$R \cap S$ are formed. The iteration continues until all waste modes are allocated in a hierarchical structure. The iteration process can be seen in Table 6.

Table 3. The structural self-interaction matrix (SSIM)

Waste Modes	*J*																	
i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		A	V	X	O	X	X	O	O	A	O	A	V	O	O	O	O	A
2			O	O	V	V	O	O	O	O	O	V	V	V	V	O	O	O
3				O	O	A	O	O	O	A	O	O	O	O	O	O	O	X
4					O	V	V	O	O	O	O	A	O	O	V	O	O	O
5						O	O	O	O	O	O	O	O	V	O	O	O	O
6							A	O	O	A	O	A	V	O	A	O	O	A
7								V	O	O	O	A	O	V	V	V	O	O
8									O	A	O	O	O	O	O	O	O	A
9										O	O	O	O	O	O	O	O	O
10											O	O	V	O	O	V	O	A
11												O	O	O	O	O	O	O
12													O	A	O	O	O	O
13														O	O	O	O	A
14															O	V	V	A
15																V	O	A
16																	O	O
17																		O
18																		

Table 4. The initial reachability matrix (IRM)

Waste Modes	*J*																	
i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		0	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0
2	1		0	0	1	1	0	0	0	0	0	1	1	1	1	0	0	0
3	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4	1	0	0		0	1	1	0	0	0	0	0	0	0	1	0	0	0
5	0	0	0	0		0	0	0	0	0	0	0	0	1	0	0	0	0
6	1	0	1	0	0		0	0	0	0	0	0	1	0	0	0	0	0
7	1	0	0	0	0	1		1	0	0	0	0	0	1	1	1	0	0
8	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
10	1	0	1	0	0	1	0	1	0		0	0	1	0	0	1	0	0
11	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
12	1	0	0	1	0	1	1	0	0	0	0		0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	1	0		0	1	1	0
15	0	0	0	0	0	1	0	0	0	0	0	0	0	0		1	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
18	1	0	1	0	0	1	0	1	0	1	0	0	1	1	1	0	0	

Table 5. The final reachability matrix (FRM) with driving power and dependence

Waste Modes	*J*																		
i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Driving power
1	1	0	1	1	0	1	1	1*	0	0	0	0	1	1*	1*	1*	0	1*	11
2	1	1	1*	1*	1	1	1*	0	0	0	0	1	1	1	1	1*	1*	0	13
3	1*	0	1	0	0	1*	0	1*	0	1*	0	0	1*	1*	1*	0	0	1	9
4	1	0	1*	1	0	1	1	1*	0	0	0	0	1*	1*	1	1*	0	0	10
5	0	0	0	0	1	0	0	0	0	0	0	1*	0	1	0	1*	1*	0	5
6	1	0	1	1*	0	1	1	0	0	0	0	0	1	0	0	0	0	1*	7
7	1	0	1*	1*	0	1	1	1	0	0	0	1*	1*	1	1	1	1*	0	12
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
10	1	0	1	1*	0	1	1*	1*	0	1	0	0	1	0	0	1	0	1*	10
11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
12	1	0	1*	1	0	1	1	1*	0	0	0	1	1*	1*	1*	1*	0	0	11
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
14	1*	0	0	1*	0	1*	1*	0	0	0	0	1	0	1	0	1	1	0	8
15	1*	0	1*	0	0	1	0	0	0	0	0	0	1*	0	1	1	0	0	6
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
18	1	0	1	1*	0	1	1*	1	0	1*	0	1*	1	1	1	1*	1*	1	14
Dependance	11	1	10	9	2	11	9	8	1	3	1	6	11	9	8	11	6	5	

***)** New relationship from transitivity test

Table 6. Iteration process

Level	Waste Rank	Reachability set	Antecedent set	Intersection
Level-I	8	8	1,3,4,7,8,10,12,1	8
	9	9	9	9
	11	11	11	11
	13	13	1,2,3,4,6,7,10,12,13,15,18	13
	16	16	1,2,4,5,7,10,12,14,15,16,18	16
	17	17	2,5,7,14,17,18	17
Level-II	1	1,3,4,6,7,14,15,18	1,2,3,4,6,7,10,12,14,15,18	1,3,4,6,7,14,15,18
	6	1,3,4,6,7,18	1,2,3,4,6,7,10,12,14,15,18	1,3,4,6,7,18
Level-III	14	4,7,12,14	2,3,4,5,7,12,14,18	4,7,12,14
	15	3,15	2,3,4,7,12,15,18	3,15
Level-IV	3	3,10,18	2,3,4,7,10,12,18	3,10,18
Level-V	4	4,7	2,4,7,10,12,18	4,7
	7	4,7,12	2,4,7,10,12,18	4,7,12
Level-VI	10	10,18	10,18	10,18
	12	12	2,5,12,18	12
Level-VII	5	5	2,5	5
	18	18	18	18
Level-VIII	2	2	2	2

4. Discussion

The series of waste elimination actions proposed in this study are not based on the waste modes ranking but based on the hierarchical sequence of waste modes generated from the ISM method. Structuring the waste modes based on their contextual relationship is like unraveling the tangled threads starting from the end. Problem solving should focus on the effectiveness of the solutions offered, not circling around the problem itself. Therefore, the hierarchical structure model helps identify the end of the problem so that the proposed action starts from the end of the problem that has the greatest impact. The end of the problem is the waste mode that affects the emergence of other waste modes. The waste hierarchical structure model generated through the ISM approach consists of eight levels (see Figure 1). The waste mode at level-VIII is the waste mode that affects the waste modes at the upper level. Meanwhile, the waste modes at level-I are the waste modes that are influenced by waste modes at levels below it. Thus, the sequence of waste elimination will start from level-VIII to level-I.

Level-VIII is occupied by the waste mode which is ranked 2nd in the observation results, namely ‘facility repairs take a long time’. Repairing facilities that take a long time will trigger the emergence of other waste modes. The action needed to overcome this mode of waste is to establish a standard procedure for repairing campus facilities with a target completion time for each request for repair of damaged campus facilities. Waste at level-VII is ‘the projector's connecting wire is faulty’ (5) and the ‘lecturer is assigned a task outside of their expertise’ (18). The use of multimedia has become an integral part of teaching and learning activities. Disturbances that are not immediately addressed for multimedia support tools will disrupt the teaching and learning process. Repairing facilities that take a long time directly affects the length of repair of damaged projectors and even lecturers are forced to help repair damaged devices so as not to hinder teaching and learning activities even though it is beyond the expertise of the lecturers.

At level-VI, there are two wastes 'the teaching load is overwhelming' (10) and 'assignments are not submitted on time by students' (12). Both of these waste modes make lecturers become too focused on teaching activities and most of the lecturer's time is wasted on preparing materials, teaching, and correcting assignments and student exams. In fact, lecturers have three main obligations: teaching, research, and community service. Too much focus only on teaching leaves the other two obligations neglected. Therefore, the teaching assignments should not only consider the number of course credits but also consider other lecturers' teaching activities such as guiding the final project. Thus, lecturers can still facilitate students who are late in submitting assignments, require remedies, or follow-up exams.

At level-V, there are two waste modes: ‘the lecturer is unable to locate a file’ (4) and ‘the lecturer spends a lot of time looking for documents, files, and journals’ (7). These two wastes are related to administrative works that must be done by lecturers and information management. Therefore, the proposal to overcome the waste modes at level V is the development of an integrated information system. Lupu et al [29] stated that every HEI requires an integrated information system that supports all its business processes and provides accurate and real time data to users in various departments. Such system will improve operating efficiency, support sound decision making and create the best educational experience possible.

There is only one waste mode at level-IV: ‘the lecturer does not participate in community service every semester’ (3). This waste is the result of the teaching assignments, administrative works, and lecturers who do a lot of things outside of their expertise. As a result, lecturers run out of time to carry out community service obligations. This waste will be resolved automatically if the actions for eliminating waste at level-VI and level-V have been implemented.

At level-III there are two waste modes: ‘the course schedule is changed by the lecturers’ (14) and ‘students are re-examined by the lecturer’ (15). Both waste modes cause additional administrative works, especially to arrange a new schedule. Learning management system can help lecturers when unable to teach synchronously. Kabassi et al. [30] found that the use of a learning management system will improve the quality of learning through blended learning. A learning management system can support blended learning which will help minimize schedule changes. The learning management system also supports online learning which will reduce the number of students requesting re-examinations because exams can be taken from anywhere.

Excessive lecturer administration work causes waste modes at level-II: ‘working outside the hours to perform administrative work’ (1) and ‘the lecturer failing to submit reports by a set deadline’ (6). Lecturers are often required to make reports with high repetition just because of the different formats at the level of study programs, faculties, and universities. The number of lecturers' administrative work that is repetitive in nature causes lecturers to spend most of their time doing administrative work that does not add value. In addition to having to do administrative work outside of working hours, lecturers are also late in collecting their reports. This condition needs to be anticipated by reducing the replication of administrative work which can actually be completed by creating an integrated information system. Utomo et al. [31] also support the idea that the integrated academic information system will effectively simplify the administrative process.

Although waste modes at level-I are influenced by waste modes at levels below it, waste modes at level-I have a direct impact on the implementation of lean in HEI. There are six waste modes entered at level-I: ‘the lecturer takes a long time to respond to student messages and questions’ (8), ‘multiple information channels are used to receive information (WhatsApp, email, hard copy, etc.)’ (9), ‘the lecturer uses the same exam questions from the previous year’ (11), ‘every semester, the lecturer does not undertake research’ (13), ‘the lecturer is late in meetings’ (16), and ‘the lecturer waits for students to come in to class’ (17). As previously proposed, the development of an integrated information system will help reduce lecturer's administrative activities so that lecturers can discuss more with students, no longer need information from many channels, lecturers can have time to carry out research obligations. Finally, the learning management system also helps lecturers come to every meeting on time because they are more flexible in arranging lectures, avoiding the use of the same exam questions over and over again, and there is no need to wait for students who are late for class.

The MICMAC diagram supports the interpretation of the hierarchical structure regarding the magnitude of the influence of each waste (see Figure 2). In the MICMAC diagram, waste modes are grouped into 4 clusters: autonomous, dependent, linkage, and driver.

1. Autonomous determinants or the first quadrant that includes waste modes with weak driving power and weak dependence: 5, 8, 9, 11, 15, and 17.
2. Dependent determinants or the second quadrant that includes waste modes with weak driving power but strong dependence: 6, 13, 14, and 16;
3. Linkage determinants or the third quadrant that consists of waste mode with strong driving power and strong dependence: 1, 3, 4, and 7;
4. Driver determinants or the fourth quadrant that includes waste mode with strong driving power but weak dependence: 2, 10, 12, and 18.

These results support the waste hierarchical structure model. Waste modes at level-VIII, level-VII, and level-VI are grouped in the driver determinant. This is in line with the ISM hierarchical structure that the waste modes at the lower level have the great influence. Waste modes at level-V, level-VI, and level-III, level-II, and level-I are included in the linkage and dependent determinants so that they act as interplay in the relationship between waste modes. Eventually, waste modes at level-I, level-III, and level-VII are grouped in the autonomous determinant.

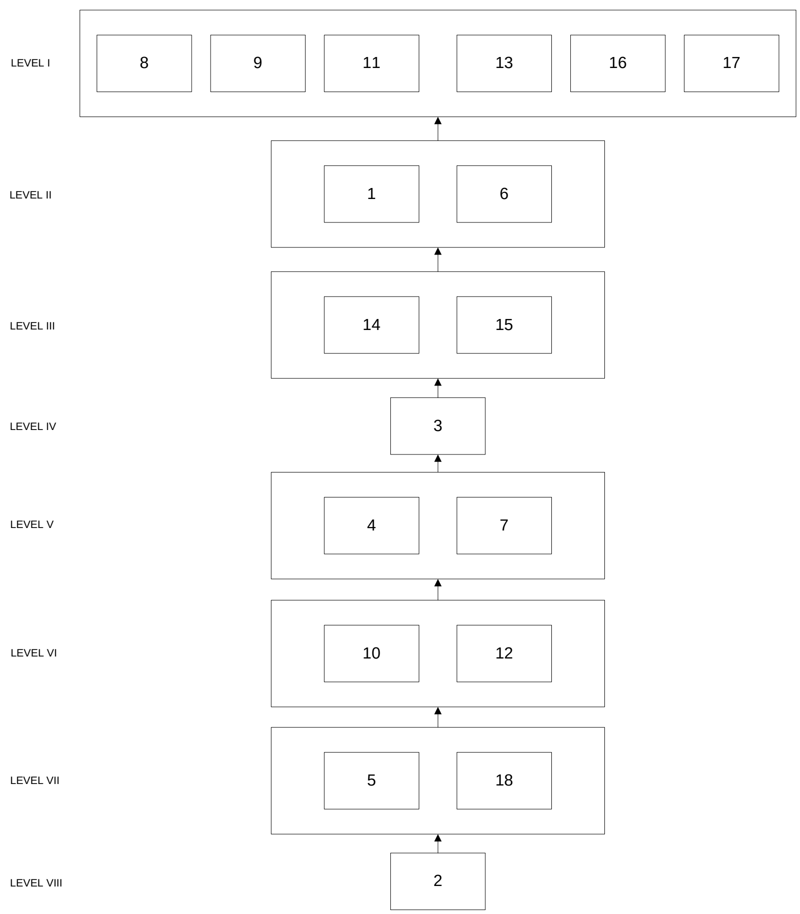

Figure 3. The waste hierarchical structure

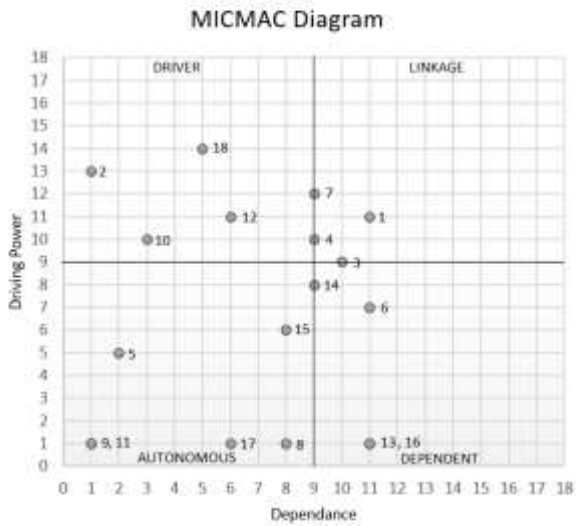

Figure 2. MICMAC cartesian diagram

5. Conclusion

Waste elimination and process improvement have been identified as critical goals of lean principles in HEI. The combination of the ISM and MICMAC approaches has successfully supported the development of a set of actions to eliminate waste and improve processes. Determination of standard procedures for repairing damaged campus facilities, the need to consider excess activity from teaching and learning activities in the teaching assignments, integration of information systems, and development of learning management systems are proposed as waste elimination actions. Implementation the proposed actions are expected to eliminate the 18 identified waste modes and improve the process. This study also found that there was no relationship between the waste mode rankings and the hierarchical structure model generated from the ISM. Waste modes that often appear do not necessarily have a strong influence on other waste modes and vice versa. Practically, this research can be directly applied to the HEI under study and other HEIs that face similar problems. Methodologically, this research is expected to provide insight into how the ISM-MICMAC approach is used as the basis for formulating effective actions in the idea of lean management. The limitation of this research is to see waste modes only from the lecturer's perspective. The suggestion for further research is that waste identification is carried out not only from the perspective of lecturers but also from the perspective of other stakeholders in the HEIs.

References

[1] Čiarnienė R and Vienažindienė M 2012 Lean manufacturing: theory and practice *Economics and Management* **17** 2 pp. 726-732

[2] Bhamu J and Sangwan K S 2014 Lean manufacturing: literature review and research issues. *International Journal of Operations & Production Management* **34** 7 pp. 876-940

[3] Suárez-Barraza M F, Smith T and Dahlgaard-Park S M 2012 Lean Service: A literature analysis and classification *Total Quality Management & Business Excellence* **23** 3-4 pp. 359-380

[4] Ahlstrom P 2004 Lean service operations: translating lean production principles to service operations *International Journal of Services Technology and Management* **5** 5-6 pp. 545-564

[5] Vignesh V, Suresh M and Aramvalarthan S 2016 Lean in service industries: A literature review *IOP Conference Series: Materials Science and Engineering* **149** 1 p. 012008

[6] Rauch E, Damian A, Holzner P and Matt D T 2016 Lean Hospitality-Application of Lean Management methods in the hotel sector *Procedia CIRP* **41** pp. 614-619.

[7] Eriksson A, Holden R J, Williamsson A and Dellve L 2016 A case study of three Swedish hospitals’

strategies for implementing lean production *Nordic Journal of Working Life Studies* **6** 1 pp. 105-131

[8] Bakri M 2019 Implementing Lean tools to streamline banking operations: A case study of a small Lebanese bank *Management Studies and Economic Systems* **4** 2 pp. 131-144

[9] Sfakianaki E and Kakouris A 2019 Lean thinking for education: development and validation of an instrument *International Journal of Quality & Reliability Management*

[10] Procter S and Radnor Z 2014 Teamworking under Lean in UK public services: lean teams and team targets in Her Majesty's Revenue & Customs (HMRC) *The International Journal of Human Resource Management* **25** 21 pp. 2978-2995

[11] M Sunder V and Mahalingam S 2018 An empirical investigation of implementing lean six sigma in higher education institutions *International Journal of Quality & Reliability Management* **35** 10 pp.2157-2180

[12] Balzer W K 2010 *Lean higher education: Increasing the value and performance of university processes* (New York: Productivity Press)

[13] Balzer W K, Brodke M H and Kizhakethalackal E T 2015 Lean higher education: successes, challenges, and realizing potential *International Journal of Quality & Reliability Management* **32** 9 pp. 924-933

[14] Sahney S, Banwet D K and Karunes S 2010 Organizational culture, Sri Lanka, public sector organizations, total quality management, hospitals: An administrative staff perspective in the indian context *TQM Journal* **22** 1 pp. 56–71

[15] Kadarova J and Demecko M 2016 New approaches in lean management *Procedia Economics and Finance* **39** pp. 11-16

[16] Cudney E A, Venuthurumilli S S J, Materla T and Antony J 2020 Systematic review of Lean and Six Sigma approaches in higher education *Total Quality Management & Business Excellence* **31** 3-4, pp. 231-244

[17] Allaoui A and Benmoussa R 2020 Employees' attitudes toward change with Lean Higher Education in Moroccan public universities *Journal of Organizational Change Management* **33** 2 pp. 253-288

[18] Waterbury T 2015 Learning from the pioneers: A multiple-case analysis of implementing Lean in higher education *International Journal of Quality & Reliability Management* 32 9 pp.934-950

[19] Qayyum A and Manarvi I 2017 Implementation of lean thinking in higher educational institutions (HEIs) *INTED2017 Proceedings* **1** pp. 699–710

[20] Thomas A, Antony J, Francis M and Fisher R 2015 A comparative study of Lean implementation in higher and further education institutions in the UK *International Journal of Quality & Reliability Management* **32** 9 pp.982-996

[21] Narayanamurthy G, Gurumurthy A and Chockalingam R 2017 Applying lean thinking in an educational institute – an action research *International Journal of Productivity and Performance Management* **66** 5 pp. 598–629

[22] Hartanti L, Mulyana I and Hartiana T 2020. Waste in higher education institution: A systematic literature review *International Journal of Scientific and Technology Research* **9** 9 pp. 16–22

[23] Kazancoglu Y and Ozkan-Ozen Y D 2019 Lean in higher education: A proposed model for lean transformation in a business school with MCDM application *Quality Assurance in Education* **27** 1 pp. 82–102

[24] Klein L L, Tonetto M S, Avila L V and Moreira R 2021 Management of lean waste in a public higher education institution *Journal of Cleaner Production* **286** p. 125386

[25] Rawabdeh I A 2005 A model for the assessment of waste in job shop environments *International Journal of Operations and Production Management* **25** 8 pp. 800–822

[26] Yadav G and Desai T N 2017 Analyzing Lean Six Sigma enablers: A hybrid ISM-fuzzy MICMAC approach *TQM Journal* **29** 3 pp. 488–510

[27] Gunawan I, Vanany I and Widodo E 2021 Typical traceability barriers in the Indonesian vegetable

oil industry *British Food Journal* **123** 3 pp. 1223–1248
[28] Jadhav J R, Mantha S S and Rane S B 2014 Development of framework for sustainable Lean implementation: an ISM approach *Journal of Industrial Engineering International* **10** 3 pp.1-27
[29] Lupu A R, Bologa R, Sabau G and Muntean M 2008 Integrated information systems in higher education *WSEAS Transactions on Computers* **7** 5 pp. 473-48
[30] Kabassi K, Dragonas I, Ntouzevits A, Pomonis T, Papastathopoulos G and Vozaitis Y 2016 Evaluating a learning management system for blended learning in Greek higher education *SpringerPlus* **5** 1 pp. 1-12
[31] Utomo H P, Bon A T, and Hendayun, M 2018. The integrated academic information system support for education 3.0 in higher education institution: Lecturer perspective. *Journal of Physics: Conference Series* **1049** 1 p. 012102